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Introduction

Developing new sites for noxious facilities has become a complex process with many potential pitfalls involving regulatory, political, and economic factors. Success may turn on the facility proposer's ability both to identify a candidate site that meets technical requirements and to respond appropriately to local population aversion to risks associated with the type of facility proposed. While the proposer's integrity is crucial to siting negotiation success, success also depends on accurate assessment of potential impacts of the facility and provision of equitable compensation to affected people.

Historically, facility impact assessments have focused on the effects of changes in population, employment and economic activity associated with construction and operation. Because of this scope limitation, such assessments have often shown a short-run, net economic benefit for the host region, making intensely negative public reaction to some types and locations of facilities seem unreasonable. Also, the long-run effect of public perceptions of both facility risk and nuisance characteristics on the area's economy has not been included. Recent developments in psychological and economic techniques have made it possible to correct this by incorporating public perceptions into projections of direct and indirect economic impacts from noxious facilities.

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Recognition of the need for more comprehensive assessments of impact and adequacy of community compensation for hazardous facility siting has led recently to development of several strategies for more explicit treatment of host population preferences. These have included quasi-auction processes[1] that depend on community self-evaluation of the compensation required to make a noxious facility worth accepting. Suggestions have been made for compensation to be tailored to address specific categories of impacts and perceived risk.[2] These approaches are as yet largely untested, although Nieves, et al.[3] found, in an analysis of recent siting activity in Wisconsin, that acceptable compensation levels are clearly related to levels and types of risks perceived in the host communities. Swallow, Opaluch and Weaver[4] have developed a method of integrating technical siting criteria, public evaluations of trade-offs among alternative resource uses, and possibly an auction to identify the final site in a multi-stage selection process designed to minimize social costs. They indicate that it might sometimes be desirable to carry out a "detailed, centralized evaluation" rather than an auction to select among the final group of siting candidates.

A framework for conducting such an evaluation, incorporating perceived risks explicitly, is developed in the following sections. Methods currently used in projecting impacts are reviewed and evaluated, and integration is recommended for what have until now been disparate lines of research in psychology and economics.

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1 Inhaber, *Of LULUs, NIMBYs, and NIMTOOs*, THE PUB. INTEREST, No. 107, Spring, 1992, at 52-63. Kunreuther & Kleindorfer, *A Sealed-Bid Auction Mechanism for Siting Noxious Facilities*, 76 AM. ECON. REV.: PAPERS AND PROC. 295 (1986).

2 Gregory, et al., *Incentives Policies to Site Hazardous Waste Facilities*, 11 RISK ANAL. 667 (1990); Zeiss, *Community Decision-Making and Impact Management Priorities for Siting Waste Facilities*, 11 ENVTL. IMPACT ASSESSMENT REV. 231 (1991).

3 Nieves, Himmelberger, Ratick, & White, *Negotiated Compensation for Solid Waste Disposal Facility Siting: An Analysis of the Wisconsin Experience*, 12 RISK ANAL., No. 4, Dec., 1992.

4 Swallow, Opaluch, & Weaver, *Siting Noxious Facilities: An Approach that Integrates Technical, Economic and Political Considerations*, 68 LAND ECON. 283 (1992).

Methods of Assessing Perception-Based Impacts

There are three major approaches for measuring or projecting elements of the psychological and behavioral processes that generate economic impacts as a result of perceived risks of noxious facilities. The first, psychometric measurement, is an extension of attitudinal scale development which provides a signal of impact potential by indicating the relative intensity of risk perception and aversion. In addition, there are two economic approaches available. One, contingent valuation, provides an ex ante measure of impacts based on survey responses to a hypothetical situation, such as a noxious facility at a given distance from the respondent's residence. The other, hedonic price analysis, is an ex post measure that can be used to estimate the value of location characteristics, such as noxious facility proximity, that affect local wages and, primarily, land prices. These approaches are discussed with examples of their implementation, and an evaluation of their potential and limitations for estimating noxious facility impacts.

Psychometric Measures

The field of psychology has produced many techniques for measuring attitudes, including both survey and experimental approaches. Some of these have been developed specifically to provide data on the ways in which people typically process information and make decisions under uncertainty.[5] Such psychometric surveys generally have a structure that elicits respondents' perceptions or reveals their thought processes by requiring respondents to rank alternatives or choose among alternative outcomes.

Psychometric methods have been applied to diverse topics, such as consumer decision making, adaptations to natural hazard risks, and aversion to noxious facilities. An early study by Golant and Burton[6] illustrates the potential scope of this method. They asked respondents to rank selected natural, physical and social hazards by the degree to which

[5] For an overview of the literature on underlying cognitive processes, *see* D. KAHNEMANN, P. SLOVIC & A. TVERSKY, JUDGMENT UNDER UNCERTAINTY: HEURISTICS AND BIASES (1982).

[6] Golant & Burton, *Avoidance-Response to the Risk Environment*, NAT. HAZARD RES. UNIV. OF TORONTO, Working Paper No. 6, 1969.

avoidance was desired. The relative rankings of hazards by persons who had, and had not, experienced them were then compared and relationships analyzed between these rankings and respondents' socio-economic and personality characteristics.

While psychometric measures provide information on risk perception and relative risk aversion, they do not indicate the extent of resulting impacts (psychological, social, or economic). What is lacking for hazard impact projection is a linkage between the attitudes described by the psychometric measures and actual physical or behavioral changes. Some work has been done relating an attitudinal measure, location image, to vacation location preferences and vacation location choices.[7] However, this research has not addressed relationships between noxious facility images and actual location choices among locations with and without noxious facilities.

Table 1

Psychometric Studies of Noxious Facility Rankings

Hazards	*Findings*
1. Gas, oil, coal and nuclear plants, LNG storage, refineries, hazardous waste, nuclear waste	Aversion ranking: gas lowest, nuclear waste highest
2. Gas works, district heating facility, oil refinery, mental hospital, nuclear reactor, prison, airport	Risk ranking: nuclear plant highest except for people living within 500 meters
3. Landfill, chemical landfill, coal and nuclear plants, refinery, pesticide mfg., nuclear waste	Aversion ranking: landfill lowest, nuclear waste highest
4. Home and job accidents, nuclear plants, hazardous chemicals, nuclear waste, nuclear weapons testing	Seriousness of risk scale: home accident lowest, nuclear waste highest

A limited number of psychometric studies focus on aversion to noxious facilities and perceived risks of technological hazards; Table 1 provides a listing.[8] In these surveys, nuclear plants and nuclear wastes

[7] P. SLOVIC, M. LAYMAN & J. FLYNN, IMAGES OF A PLACE AND VACATION PREFERENCES: IMPLICATIONS OF THE 1989 SURVEYS FOR ASSESSING THE ECONOMIC IMPACTS OF A NUCLEAR WASTE REPOSITORY IN NEVADA (1990).

have consistently received among the highest rankings in regard to perceived risks. This ranking transcends geographical boundaries; the first three studies were conducted in the U.S., while the last was conducted in Europe. Some variation in risk evaluations is shown among groups surveyed, however. Lindell and Earle,[9] for instance, found that nuclear engineers as a group are most willing to live near a nuclear plant, while environmentalists are least willing to do so. Maderthaner, et al.[10] found that those presently living in close proximity to a nuclear plant rated it as less risky than did those living at a greater distance. Regardless of whether these differences are due to variations in familiarity with the technology or to self-selection into the residential distance groups, they indicate the potential of psychometric techniques to identify differences in risk perceptions among population subgroups. Both of the surveys reported by Mountain West[11] and by Kunreuther, et al.[12] were conducted as part of a larger research program for the State of Nevada. Unfortunately, the Mountain West[13] question eliciting relative perceptions of the facilities is worded in such a way that interpretation of the responses is ambiguous: "For each type of facility please tell me the closest such a plant could be built from your home before you would want to move to another place or to actively protest, or whether it wouldn't matter to you one way or another how close it was? Please answer in number of miles." This wording assumes that moving and protesting are triggered at the same threshold level of risk perception.

8 The research was done, respectively, by: (1) Lindell & Earle, *How Close is Close Enough: Public Perceptions of the Risks of Industrial Facilities*, 3 RISK ANAL. 245 (1983); (2) R. MADERTHANER ET AL., PERCEPTION OF TECHNOLOGICAL RISKS: THE EFFECT OF CONFRONTATION (1976) [hereinafter MADERTHANER]; (3) MOUNTAIN WEST RESEARCH, YUCCA MOUNTAIN SOCIOECONOMIC PROJECT PRELIMINARY FINDINGS: 1989 NEVADA STATE TELEPHONE SURVEY (1989) [hereinafter MOUNTAIN WEST]; and (4) Kunreuther, Desvousges & Slovic, *Nevada's Predicament*, 30 ENV'T 17, 30 (1988).

9 Lindell & Earle, *supra* note 8.

10 MADERTHANER, *supra* note 8.

11 MOUNTAIN WEST, *supra* note 8.

12 Kunreuther, *supra* note 8.

13 *Supra* note 8.

Few of the psychometric studies to date have both 1) used a national sample and 2) elicited perceptions of a broad range of facility types. Studies either include a variety of facilities but are based on limited samples or are based on a national sample but include only a few facility types.[14] At present there is no national analysis available of relative risks perceived in connection with a wide range of noxious facilities. Such a study could reveal differences in risk perceptions across regions and among population subgroups that affect both the feasibility and the impacts of siting new facilities. There is also a possibility that risk perceptions of subgroups will be differentially affected by alternative forms of compensation or methods of providing community control over aspects of facility operation. These issues have not been explored.

Contingent Valuation

Contingent valuation is the term applied to the technique of asking people to place monetary values on goods or environmental changes for which no market exists. It usually involves questions about the amount that a household would be willing to pay for an improvement in environmental quality or be willing to accept for a decrease in quality. Questions can also be framed in terms of likely changes in household behaviors, such as visits to a location, or choice of housing location at alternative distances from a noxious facility.

As Randall, et al.[15] note in their review of contingent valuation methods, because the respondent is asked to evaluate a hypothetical situation, precise specification is required of the environmental change, the organizational framework controlling it, and the mechanisms for any monetary transfers. Brookshire and Crocker[16] indicate that the degree to which the impact estimates developed by contingent valuation methods correspond to actual impact is dependent on the accuracy and imaginability of the information provided to survey respondents. Though caution is needed in applying this method, the hypothetical

14 *See, e.g.*, Kunreuther, *supra* note 8.

15 Randall, Hoehn & Brookshire, *Contingent Valuation Survey for Evaluating Environmental Assets*, 23 NAT. RESOURCE J. 635 (1983).

16 Brookshire & Crocker, *The Advantages of Contingent Valuation Methods for Benefit-Cost Analysis*, 36 PUBLIC CHOICE 235 (1981).

nature of contingent market valuation is also the main reason for its value, in that it provides a method of ex ante evaluation of noxious facility impacts.

The type of information that can be obtained from a contingent valuation survey is well demonstrated by Bajgier and Moskowitz's[17] study of the relative importance of perceived risks in willingness to pay for contaminant removal from drinking water. They examine beliefs about contamination of respondents' own drinking water and that of others, and the role of water characteristics such as hardness in determining perceptions of water quality. The effect of providing information about drinking water quality and about relative risks to life and health is also investigated. They find that people are willing to pay more to avoid a given statistical risk if the cause of the risk is specified than if it is not, and that they are willing to pay the most to avoid risks from radioactive contaminants (more than for an unspecified "carcinogen"). This finding illustrates the need to obtain information on perceptions of risks in order to project impacts rather than depending on strictly statistical or technical estimates of risks.

While contingent valuation studies have been used to value a variety of environmental resources and changes in their quantity or quality, few have involved a noxious facility site. In one such survey, Smith and Desvousges[18] obtained bids for residential area changes in risk levels associated with a hypothetical hazardous waste landfill. The respondents were willing to pay more to reduce risk by a given amount than they were to avoid an equal increase in risk level. The authors attribute this finding[19] to a property rights effect — a belief on the part of the respondents that they are entitled to the status quo and should not have to pay to limit risk increases. As a result, when people feel that their

[17] Bajgier & Moskowitz, *Public Risk Assessment and Evaluation of Drinking Water Quality*, 1 J. OF INTERDISCIPLINARY MODELING AND SIMULATION 143 (1978).

[18] Smith & Desvousges, *Asymmetries in the Valuation of Risk and the Siting of Hazardous Waste Disposal Facilities*, 76 AM. ECON. REV.: PAPERS AND PROCEEDINGS 291 (1986); Smith & Desvousges, *An Empirical Analysis of the Economic Value of Risk Changes*, 95 J. OF POL. ECON. 89 (1987).

[19] Which is inconsistent with the theory developed by Kahneman, *see supra* note 5.

rights are violated by the environmental change being evaluated, contingent valuation may not be a reliable measure of impacts.

In spite of the potential for contingent valuation to produce an ex ante measure of noxious facility impacts, applications have been limited by survey costs and the sensitivity of results to question framing. Several types of potential bias have been identified, of which strategic bias has the most serious implications for noxious facility impact projections. This bias occurs when people give responses that do not truly reflect their personal willingness to pay for an environmental change, but seek instead to influence the study's outcome. This type of response is most likely when the respondent expects to be personally affected by a particular environmental change. Several studies have examined the potential for strategic bias. Brookshire and Crocker[20] and Randall, et al.[21] conclude that there is no clear evidence of it in practice. Seller, et al.[22] suspect its presence in their results, and Cronin,[23] in a study designed to explicitly test for strategic and other forms of bias, finds significant evidence of it. It also may be operative in a survey dealing with willingness to accept compensation for a high-level radioactive waste repository (for which Nevada is the only candidate location) reported by Kunreuther, et al.[24] They found willingness to accept compensation to increase with hypothetical distance to a repository in a national sample but not in the Nevada sample.

Hedonic Price Estimation

Hedonic models use price data for a related market to measure the value of environmental goods (or bads) that are not themselves traded in markets, thus providing an estimate of the implicit value that people ascribe to the environmental characteristic. Most applications of hedonic methods have analyzed single-family residence prices, although there

20 *Supra* note 16.

21 *Supra* note 15.

22 Seller, Stoll & Chavas, *Validation of Empirical Measures of Welfare Change: A Comparison of Nonmarket Techniques*, 61 LAND ECON. 156 (1985).

23 F.J. CRONIN, VALUING NONMARKET GOODS THROUGH CONTINGENT MARKETS (1982).

24 *Supra* note 8.

have been a few studies involving rental housing prices and, also, wages. The hedonic approach assumes that consumers perceive goods as bundles of features and that goods with all possible combinations of the features are available in the market. For housing, the relevant features are attributes such as age of structure, number of rooms, lot size, garage, fireplaces, neighborhood characteristics, and environmental conditions such as crime rate, climate and access to recreational opportunities. The implicit value of each of these attributes can be measured by regression analysis of the response of price to the relevant attributes. The implicit attribute price is interpreted as a representative household's willingness to pay for an additional unit of that attribute.

Hedonic models have been commonly used to value disamenities such as air-pollution concentration levels, risks associated with flood plain or earthquake zone locations, and proximity to noxious facilities. In valuing impacts, the hedonic approach estimates the net value of the presence of a disamenity including its effect on employment, local income, traffic, noise, perceived risks, etc. in the long-run (after local markets have adjusted to siting of a facility). Therefore, the finding of a negative implicit price for a noxious facility implies that the value of the associated nuisance effects and perceived risk effects is greater than the value of stimulating effects of the facility on the local economy.

Hedonic methods have been found to produce relatively consistent results across locations[25] and studies of area-wide environmental conditions have found that many have statistically significant effects on price levels in the market analyzed. Roback's work,[26] which evaluates a variety of amenities and disamenities, is especially important because it examines the relationship between property and labor markets and shows that environmental attributes affect prices in both, simultaneously. Disamenities, such as noxious facilities, can lower property values, or raise wages, or both. Many studies analyzing the

[25] Freeman, *Hedonic Prices, Property Values and Measuring Environmental Benefits: A Survey of the Issues*, 1979 SCANDINAVIAN J. OF ECON. 154.

[26] Roback, *Wages, Rents and the Quality of Life*, 90 J. OF POL. ECON. 1257 (1982).

implicit prices of perceived risks or nuisances have not addressed the issue of property and wage market interrelationships and, thus, have produced biased implicit price estimates for disamenities. Methods have been developed of estimating unbiased implicit prices for area characteristics using either property[27] or labor market data[28] and controlling (in the hedonic regression equation) price levels in the other market. This technique can be used to estimate noxious facility impacts with detailed data for only one market, but may be even more valuable as a means of confirming impact estimates by developing values separately for each market.

Hedonic property value studies[29] are listed in Table 2. Most evaluate

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[27] Clark & Cosgrove, *Hedonic Prices, Identification, and the Demand for Public Safety*, 30 J. OF REGIONAL SCI. 105 (1990).

[28] Henderson, *Evaluating Consumer Amenities and Interregional Welfare Differences*, 11 J. OF URBAN ECON. 32 (1982).

[29] The findings were made, respectively, by: (1) McClelland, Schulze & Hurd, *The Effect of Risk Beliefs on Property Values: A Case Study of a Hazardous Waste Site*, 10 RISK ANALYSIS 485 (1990) [hereinafter McClelland]; (2) R. SCHMALENSEE, R. RAMANATHAN, W. RAMM, & D. SMALLWOOD, MEASURING EXTERNAL EFFECTS OF SOLID WASTE MANAGEMENT (1975); (3) D. HARRISON & J.H. STOCK, HEDONIC HOUSING VALUES, LOCAL PUBLIC GOODS, AND THE BENEFITS OF HAZARDOUS WASTE CLEANUP (1984); (4) Michaels & Smith, *Market Segmentation and Valuing Amenities with Hedonic Models: The Case of Hazardous Waste Sites*, 28 J. OF URBAN ECON. 223 (1990); (5) Hoehn, Berger & Blomquist, *A Hedonic Model of Interregional Wages, Rents, and Amenity Values*, 27 J. OF REGIONAL SCI. 605 (1987) [hereinafter Hoehn]; (6) Grether & Mieszkowski, *The Effects of Nonresidential Land Uses on the Prices of Adjacent Housing: Some Estimates of Proximity Effects*, 8 J. OF URBAN ECON. 1 (1980); (7) Burnell, *Industrial Land Use, Externalities, and Residential Location*, 22 URBAN STUD. 399 (1985); (8) Blomquist, *The Effect of Electric Utility Power Plant Location on Area Property Value*, 50 LAND ECON. 97 (1974); (9) M.D. BAKER, PROPERTY VALUES AND POTENTIALLY HAZARDOUS PRODUCTION FACILITIES: A CASE STUDY OF THE KANAWHA VALLEY, WEST VIRGINIA (1986); (10) Gamble & Downing, *Effects of Nuclear Power Plants on Residential Property Values*, 22 J. OF REGIONAL SCI. 457 (1982); (11) Nelson, *Three Mile Island and Residential Property Values: Empirical Analysis and Policy Implications*, 57 LAND ECON. 363 (1981); (12) REAL ESTATE COUNSELING GROUP OF CONNECTICUT, INC. & FINANCIAL CONSULTING GROUP OF OHIO, PATTERNS OF REAL ESTATE MARKET BEHAVIOR AROUND THE FEED MATERIALS PRODUCTION CENTER FERNALD, OHIO, VOL. I AND II (1987 & 1989) [hereinafter REAL ESTATE COUNSELING GROUP]; and (13) Clark & Nieves, *An Interregional Hedonic Analysis of Noxious Facility Impacts on Local Wages and Property Values*,

the effects of noxious facilities by case studies of one, or several, individual communities.

Table 2
Hedonic Studies of Noxious Facility Impacts on Property Values

Noxious Facilities	*Findings*
1. Landfill	Presence of perceptual signals (e.g. odor) tied to health risk beliefs is associated with lower values.
2. Landfill	Prices lower near garbage truck route, freeway and gravel pit. Values unaffected by landfill distance within the study radius.
3. Landfill, industrial sites, hazardous waste	Proximity to industrial sites increased prices. Hazardous proximity lowered them.
4. Hazardous waste sites	Proximity to sites lowers values.
5. Superfund sites; waste treatment sites	Net impacts on wages and housing values combined are negative.
6. Public housing, industry, commercial development	Industry and public housing prices lowered. No effect due to commercial development.
7. Manufacturing	Industry increased values but air polluting industries lowered them.
8. Coal-fired electric plant	Proximity to plant lowers prices.
9. Chemical manufacturing	Proximity to chemical plants and higher levels of air pollution lowered prices. No change due to Bhopal accident.
10. Nuclear plants	No significant effect on values.
11. Three Mile Island	No price change due to TMI accident.
12. Nuclear materials production	Increase in sales prices after announcement of discharge. Distance effect unclear.
13. LNG storage; chemical weapons storage; coal, gas and oil, and nuclear plants; refineries; radioactive contaminated sites: hazardous waste sites	Chemical weapons storage; coal, gas and oil and nuclear plants; and refineries decrease home values. Hazardous waste and LNG storage sites are associated with higher values.

These studies typically focus on identification of property value gradients related to distance from the study facility. While these studies are highly consistent in finding facility proximity to be associated with depressed property values, they do not provide a good basis for generalizing to other sites or projecting impacts for sites that do not yet

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have a facility. Because the basis of analysis is a single community, these studies do not control for characteristics (that affect property values) which vary across communities, such as population density, climate, and other amenities and disamenities.

Only two of the studies listed use an interregional modeling approach that controls for differences in basic community environment when measuring the effects of noxious facilities; the remainder are limited to a single locality. (This approach has been employed, however, in numerous hedonic analyses of impacts of crime rates, climatic characteristics, etc.) In the first of these, Hoehn, et al.[30] calculate a net impact on wage and property markets combined, for Superfund sites and hazardous waste treatment, storage, and disposal sites. This impact measure takes the simultaneous interaction of wage and property markets into account and demonstrates that both types of sites have depressing net effects on the local markets. The second study[31] finds lower property values as the density of each facility type increases, except for hazardous waste sites, radioactive contaminated sites and LNG (liquefied natural gas) storage sites. Net income and property value impacts for seven of the eight facility types studied were found to be negative.

Hedonic estimation techniques have undergone substantial development during the 1980's with the result that many of the earlier studies can at this point be faulted on methodological grounds. In addition, many of the property value study findings may have been affected by the small size of the region studied. Most of these studies find price gradients that decrease with increasing distance from a noxious facility, but lack the basis for determining whether the price level in the whole area differs from that in comparable areas. Wage studies, though based on national samples, have generally not dealt with employment in or near noxious facilities.

In spite of the methodological flaws and limited scope of the existing research, there is a broad consistency to the findings. Within the wage

30 Hoehn, *supra* note 29.

31 Clark & Nieves, *supra* note 29.

analyses, positive wage differentials for exposure to risks are clearly documented. The property studies generally indicate that values are lower in proximity to noxious facilities. Where the effects of an accident are evaluated,[32] no price impacts are found, indicating that public expectations of such accidents consistent with the incident were already fully capitalized into property prices. In addition, there are indications in two studies that found insignificant or positive price impacts, that damage compensation (or expectations of it) may have been responsible for maintaining property values.[33] The studies that permit assessment of net impacts on labor and property markets nationally[34] indicate a net negative effect associated with several types of noxious facilities.

Comparison of Economic and Psychometric Risk Aversion Measures

Currently, no contingent valuation studies allow ranking the intensity of public aversion to various types of noxious facilities. One hedonic study[35] and two psychometric studies[36] provide information for a sufficient variety of facility types to permit comparison of findings on public aversion to facility proximity. Data from these studies are summarized in Table 3 which presents both the study findings for six facility types and a ranking constructed from the study findings.[37] The two psychometric studies provide cardinal (absolute) measures, in miles or in population percentage, for public aversion to noxious facilities. Findings of these two studies, while not based on comparable samples or questions, produce a consistent relative ranking for the three facility types that they have in common. The intensity of aversion to nuclear plants is substantially greater than that for petrochemical refineries, which, in turn, is somewhat greater than for coal-fired power plants.

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32 BAKER, *supra* note 29; Nelson, *supra* note 29.

33 Gamble & Downing, *supra* note 29; REAL ESTATE COUNSELING GROUP, *supra* note 29.

34 Hoehn, *supra* note 29; Clark & Nieves, *supra* note 29.

35 Clark & Nieves, *supra* note 29.

36 Lindell & Earle, *supra* note 8; MOUNTAIN WEST, *supra* note 8.

37 Each study also included facility types that were not included in the other two studies, and these are omitted from this comparison.

Table 3
Comparison of Economic and Psychometric Measures

Comparative Measures	*Facility Types*					
	Refinery	*Hazardous waste*	*Nuclear plant*	*Coal plant*	*Oil/gas plant*	*LNG storage*
Aversion intensity (mean miles) [a]	251	925	791	212	N/A	N/A
Ranking	3	1	2	4	—	—
Aversion intensity (population %) [b]	48.3	N/A	64.5	40.9	27.2	51.0
Ranking	3	—	1	4	5	2
Economic impacts (1980$)[c]	–468	49	–563	–118	–45	–214
Ranking	2	6	1	4	5	3

[a] Defined as closest distance from facility site to home before respondent would want to move or actively protest. Based on responses to a national survey (Mountain West 1989).
[b] Defined as percentage of all respondent groups (from a survey of six population subgroups) unwilling to live or work within ten miles of a facility (Lindell and Earle 1983).
[c] Defined as median change in the sum of property value and income impacts per household from a one unit increase in total facility density (per 100 square miles). Based on hedonic estimation for 84 representative areas of the U.S. (Clark and Nieves 1991).

The economic impact measures for the six facility types are shown in 1980 dollars of net annual income and property value response to a one unit increase in facility density (per 100 square miles). This measure shows similar impact magnitudes for nuclear plants and refineries, followed by coal-fired plants, LNG storage facilities, and then by oil- and gas-fired plants. Hazardous waste sites had a positive effect on residential property values in 1980 (before they were publicly identified as "Superfund" sites). Their ranking is the only one that differs substantially from the relative ranking produced by the psychometric studies. These economic impacts represent the net value of economic stimulus effects and the negative impacts of risk aversion and nuisance perception. The hazardous waste sites are apparently associated with economic activity with benefits to the local economy that outweigh any

negative impacts due to public risk perception based on site-specific information available in 1980. For the other five facility types, risk and nuisance effects outweigh economic benefits.

The finding of negative impacts in the hedonic valuation of facility sites confirms that public perceptions of risk and nuisance effects have a measurable economic consequence. Determining the magnitude of this impact in addition to the economic stimulus component requires incorporating information regarding public aversion to facilities into economic analyses of facility impacts in such a way that the components can be delineated. A method of accomplishing this is suggested in the following section.

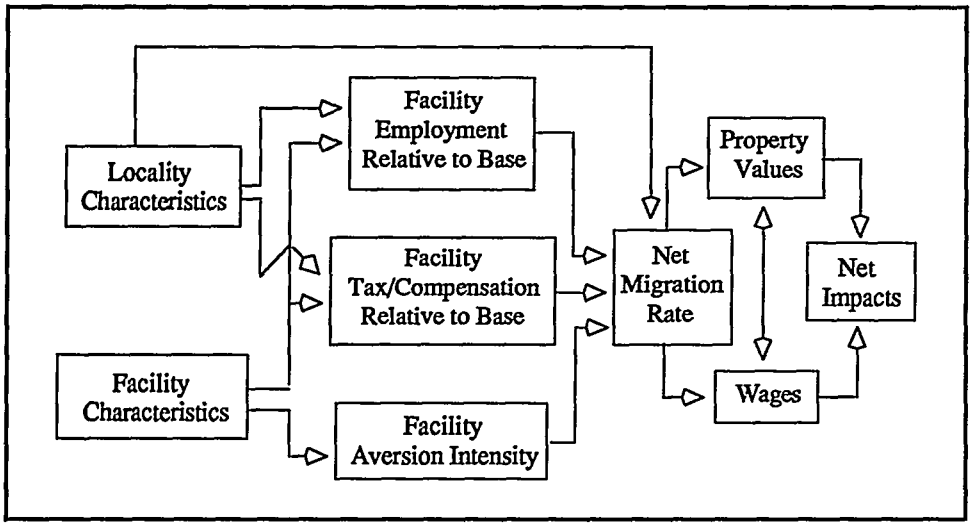
Potential for Method Integration

Predictive models of perception-based impacts have not been developed, and no economic estimates of such impacts exist. Methods are available, however, that can be linked to estimate the components of noxious facility impacts, including those due to risk aversion. The estimation process requires development of a baseline of information for a cross section of facilities and host communities and then projection of impacts for a specific facility/community combination from parameters estimated from the baseline data. The key elements in this baseline are: 1) information from hedonic analysis of relationships between characteristics of host areas and property and wage market impacts associated with various types of noxious facilities, and 2) psychometric information on population subgroups' aversion to the type of noxious facility being sited.

Figure 1 is a diagram of the overall structure of the elements contributing to economic impacts of facilities on property values and wages. The key factors in predicting facility impacts are the changes from the status quo which provide an impetus for changes in behavior. Two of these variables are likely to create incentives for in-migration. The most important of these is the magnitude of facility employment relative to the employment base in the host area. New employment opportunities may have a nonlinear, stimulating effect on migration depending on whether the new employment is 50%, 5% or .5% of the

base level. There may also be differential effects depending on the absolute size of base employment and the capacity of the existing infrastructure for expansion of services.

Figure 1
Key Factors Contributing Facility Net Impacts



The magnitude of facility tax payments or compensation relative to local government revenues is the second key element. In some cases a facility may tend to induce in-migration (or dampen out-migration) by decreasing the taxes paid by local residents relative to the quantity or quality of government services provided. Better services for given tax rates or lower tax rates for given service levels may be brought about by taxes paid by the facility, payments in lieu of taxes, or direct compensation to host community organizations. A recent study by Stull and Stull[38] points to the effect of local income tax rates on property values while one by Gyourko and Tracy[39] examines the effect in labor markets. The higher the expected compensation, the less wages must rise and the less property values must fall to attract in-migrants. The provision of compensation (above average rates of taxation) to local

[38] Stull & Stull, *Capitalization of Local Income Taxes*, 29 J. OF URBAN ECON. 182 (1991).

[39] Gyourko & Tracy, *The Importance of Local Fiscal Conditions in Analyzing Local Labor Markets*, 97 J. OF POL. ECON. 1208 (1989).

governments for facility siting may reduce negative facility impacts. Treating this factor separately in the model will permit estimation of the compensation required to avoid negative economic impacts. Figure 1 In contrast to the economic stimulus effects, there are two facility characteristics that determine aversion intensity and motivate out-migration. These are the degree to which the facility is perceived to be a nuisance and the degree to which it is perceived as risky. The nuisance effects of a facility depend on characteristics such as noise, odor, dirt, traffic congestion, etc. Numerous studies have shown that proximity to airports and freeways reduces property values, probably due to the effects of noise. Some nuisance characteristics such as traffic congestion and odor[40] may also serve to remind the public of potential risks, consequently triggering aversion tendencies. This limits the potential for estimating impacts from risk perception and from nuisance effects separately. Linkage between facility aversion intensity and the potential for increased out-migration is indicated both by psychometric studies in which people have stated their desire to avoid proximity to facilities considered risky and by hedonic studies that have found depressed property values in areas around noxious facilities that are major sources of local employment.

These factors can be explicitly incorporated in hedonic models of housing values and wages that control for local characteristics:

Housing Land Values = f(HS, LC, FC, AI)

Wages = f(WC, LC, FC, AI)

where

HS = a vector of housing characteristics such as lot size, room types and numbers, utilities, air conditioning, etc.

WC = a vector of worker characteristics such as age, education, sex, race, occupation, etc.

LC = a vector of local characteristics such as climate, recreational resources, region, cost-of-living index, employment growth rate, fiscal factors, etc.

FC = a vector of facility characteristics for each type of facility including facility employment percentage of total local employment, facility taxes or local compensation as a percentage of local government revenues.

40 McClelland, *supra* note 29.

AI = public aversion intensity expressed as preferred residential distance.

Explicitly incorporating aversion intensity in the model requires data on the degree to which people desire to avoid proximity to different types of noxious facilities including the type of facility for which impact estimates are desired. This information should be developed from a survey of sufficient size to permit analysis of differences in response by study area. The relative intensity of aversion to different types can then be related to the parameters estimated from historical patterns of labor and property market adjustments to project the likely market adjustments in response to facility siting, even for a new type.

Potential and limitations of this approach.

Incorporating psychometric measures of facility-related risk aversion in projecting economic impacts provides a basis for ex ante estimates of long-run market adjustments to noxious facility siting. The possibility of increasing the comprehensiveness, and therefore the accuracy, of impact estimates has both efficiency and equity implications. Combining regional economic data with information on the risk perceptions of regional populations makes it possible to identify the areas, from among a group of candidate sites, that will experience the least negative facility impacts. It also makes possible the development of risk management and impact compensation measures that are responsive to the local population's attitudes and economic situation.

While the approach described above provides a means of developing ex ante estimates for perception-based economic impacts, it involves the application of methods which have been individually tested in a variety of contexts but have never been integrated in the manner suggested here. There is a potential for difficulties to arise from the complexity of the estimation required and from the fact that in attempting anything new there is a potential for encountering the unexpected. In addition, it must be recognized that the resulting impact estimates would not be for risk perception alone, but for nuisance effects as well.

Developing impact estimates for a nonexistent type of facility requires collection of survey data regarding peoples' projection of their aversion to its hypothetical existence. While the accuracy of their

responses depends on the degree to which they can envision the future reality of the facility, this is the best measure of actual perceptions that can be obtained. The accuracy of the responses should increase as aspects of the facility become increasingly well defined. If psychometric estimates of aversion intensity for a new type of facility are used to project economic impacts, it is possible that the impact projections will be outside the range of historical experience. In such a case, the uncertainty associated with the impact estimate will be greater than for impact projections for existing types of facilities. This situation is unavoidable; the choice is between imperfect impact projections and no information at all. Under these circumstances it would be advisable to conduct a contingent valuation survey as an additional confirmatory measure.